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CSIRO Submission 19/676

Growing Australian agriculture to $100 billion by 2030

House Standing Committee on Agriculture and Water Resources

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Why CSIRO is responding to this inquiry

CSIRO operates from facilities in all States and territories and so is uniquely placed to help shape the nation's agricultural industries through R&D. Over the last 100 years its agri-food focus has changed from 97% of the organisation's activity in 1926/27 to around 30% today. This still represents around $350 million p.a. of which around $200 million comes from Australian Government funding to CSIRO and the balance from external sources such as the rural research and development corporations, other government programs and private sector sources.

CSIRO has a 100-year history of conducting research and innovation to underpin the increase in farm gate output. Notable achievements include the establishment of the cotton industry, adapted breeds for the northern beef industry, introduction of break crops into cereal-based rotations, new wine varieties, and the rapid growth of the Tasmanian salmon industry[1].

The $100B goal

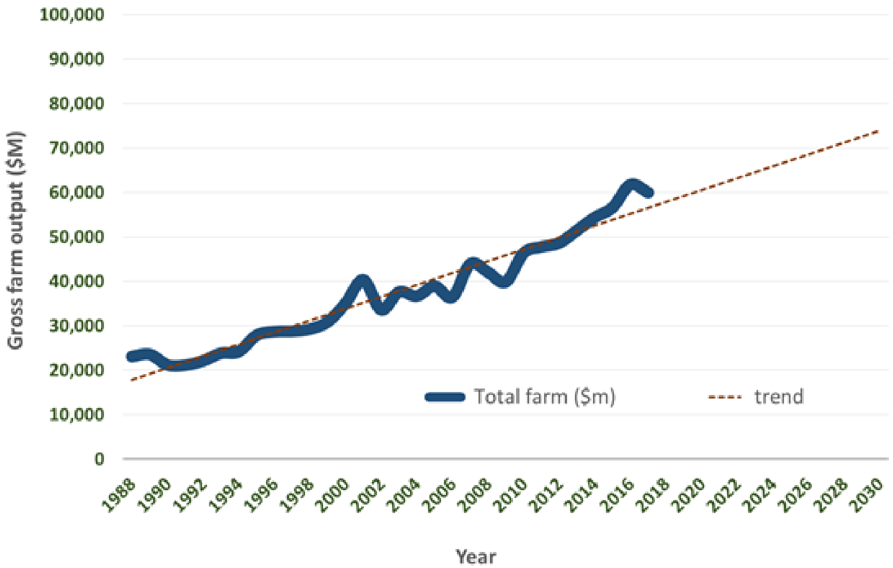
We recognise the value of the agriculture sector having an aspirational goal to drive growth, innovation and profitability. Nonetheless, we would like to point out some aspects of the goal as framed. This will allow all stakeholders to approach the goal realistically and calibrate our progress towards achieving it.

Firstly, farm gate output does not equate to profitability, which is the main driver for farmers.

Secondly, farm gate output is a product of three components: the area under production in the sector multiplied by the volume of product produced per unit area multiplied by the price received at farm gate per unit of product. An increase in farm gate output can come about through all or some of these three components. The recent ABARES forecast for national productivity highlights this[2]. Whilst production is lower than some recent years, high commodity process and a lower valued Australian dollar have dampened the effect on the value of production.

Thirdly, farm gate output does not quantify the value created by the whole of the agri-food sector, given that a large multiplier beyond the farm gate accrues through processing and value adding. There is much to be gained by growing revenue beyond the farm gate for a wide range of participants in the agrifood sector.

Figure 1: Australian farm gate output and extrapolation of historical linear trend out to 2030. Data from ABARES.



[1] https://www.csiro.au/en/Research/AF

[2] http://www.agriculture.gov.au/abares/publications/insights/2018-drought-analysis

Fourthly, extrapolating the recent historical trend of farm gate output out to 2030 shows that based on current performance the sector will reach $70 billion at best (Figure 1). This means that "business as usual" won't allow us to reach the $100 billion goal unless something transformational happens.

The clearest pathway to generating the extra growth is through greater focus on growing high-quality high value commodities which through effective marketing and reliable supply chains grows exports into growing high value markets. The greatest opportunities for this currently sit in the horticultural sector given the strong Asian demand for quality Australian fruit and veg. Australian horticulture needs to take advantage of market pull to develop better systems of supply chain integrity for quality and low pest and disease prevalence (to circumvent biosecurity non-tariff trade barriers), supported by traceability and provenance support technologies to guarantee quality, safe and clean commodities to feed those markets.

A framework to quantify and analyse targets and options

We suggest the use of a framework developed by Keating et al. (2014)[3] to describe a method for analysing different pathways for future increases in agricultural production. The pathways not only consider raising farm production, but also reduce future losses in food supply. Keating et al. (2014) proposed a framework of 14 distinct pathways for future increases in global agricultural production: pathways that target reducing food demand, pathways that increase food production, and pathways that avoid losses in current or future food supply. While their analysis was applied to the global scale there is no reason why it could not be used for the national, sub-national or industry scale. In the case of the $100B goal for Australia we suggest a focus on pathways relevant to farm production and therefore that target increasing food production and avoiding losses (and not pathways that reduce food demand). Also, a new pathway is necessary to add to the framework that accounts for added value to products or new products that result in increases in price received at the farm gate.

We suggest eight of Keating et al.'s 14 pathways are relevant here:

1. expanding the net land footprint
2. expanding the irrigation water supply
3. closing yield gaps in existing systems
4. new systems that intensify land and water use
5. genetic improvement of plants and animals
6. minimising impact of biotic stresses
7. avoid land and water degradation and
8. adapting to unavoidable climate change

These are listed in Table 1 along with the additional pathway for price increases.

*Table 1: Pathways for future increases in agricultural production with our preliminary and subjective ratings of how significant they will be in meeting the $100B target. * = insignificant to ***** = highly significant*

	Pathway for production increase/avoidance of loss	Contribution to reaching $100B goal
1	Expanding the net land footprint	*
2	Expanding the irrigation water supply	*
3	Closing yield gaps in existing systems	***
4	New systems that intensify land and water use	**
5	Genetic improvement of plants and animals	**
6	Minimising impact of biotic stresses	***
7	Avoid land and water degradation	****
8	Adapting to unavoidable climate change	****
9	Price increases through added value to products or new products	***

[3] Keating BA et al. Food wedges: Framing the global food demand and supply challenge towards 2050. *Global Food Security* 3 (2014) 125–132

Table 1 gives our subjective assessment of how significant each pathway will be in contributing to the $100B. What follows is some commentary on those ratings. All nine of the pathways merit closer and more comprehensive analysis, and our role in this submission is to simply illustrate what could be done given more time, resources and a mandate.

Prospects for expanding the net land footprint and expanding the irrigation water supply

In Australia, the prospects for expansion of the area devoted to key commodities are limited. For example, in cropping a lack of suitable soils for crop production, shortages of water for irrigated crops such as cotton and rice, the need to maintain enterprise diversity and non-crop phases in rotations are all likely reasons for limited prospects for expansion in the area for crop production. In the case of dairy and irrigated horticulture, water supplies for irrigation will also limit the scope for industry expansion[4].

The high rainfall zone (HRZ) in southern Australia (450-800 mm/yr) covers ~20M ha, of which ~4Mha are thought to be arable. An expansion of crop production into traditional grazing areas in the HRZ is now possible through the development of adapted crop varieties and new agronomic practices to address soil constraints. While such expansion has the potential for significantly increasing profitability and income stability of farming enterprises in the HRZ it is difficult to imagine an expansion of grain production over more than 50% of the 4 M ha available due to enterprise mix and rotational constraints. It is notable that the total increase in area under grain crops over the last 40 years has been about 8 M ha. Another 2 M ha from the HRZ devoted to grain production would maintain this impetus for a further decade or so.

In recent times, as water constraints for agriculture in southern Australia have become more acute, attention has turned to northern Australia. An analysis by a government taskforce[5] concluded that while there are potentially ca 17 million ha of soils suitable for annual crops and as much as ~32 million ha suitable for forestry, there is probably only water sufficient to exploit ca 60,000 – 120,000 ha, or less than 1% of this potential via irrigation. Groundwater appears to be the source of water most likely to sustain new development of irrigated agriculture in northern Australia. Whereas surface water favours development of a small number of centralised irrigation schemes (such as the Ord River Irrigation Area), groundwater is best suited to supporting a larger number of small scale and widely dispersed irrigation developments.

While the scope for areal expansion of agriculture's footprint is limited, where it will occur must be accompanied by rigorous, comprehensive, and consultative analysis of the impacts on natural resources, native ecosystems, and communities. CSIRO's work in northern Australia, funded by the Australian government, is a good example of where the analysis of options for expansion can inform thoughtful planning and investment decisions. This will also apply in other situations such as expansion of aquaculture in sensitive coastal ecosystems, the growth in the area under irrigated perennials in the Murray Darling Basin, or high input horticulture in peri-urban areas.

Prospects for increases in production per unit area

Prospects for increases in production per unit area is a measure that is a combination of two of the Keating pathways: closing yield gaps and genetic improvement. More data and effort would be required to decompose into these two components. However, for now we present rates of improvement in farm production taken from ABARES data (Table 2).

Measures across a range of industries (Table 2) show that in some cases rates of increase have been strong (e.g. cotton, maize, dairy), while others have slowed (e.g. temperate grains) or remain static (e.g. wool).

[4] Robertson MJ 2010. in Proceedings of 15th Agronomy Conference 2010

[5] https://www.csiro.au/en/Research/Major-initiatives/Northern-Australia/Current-work/NAWRA

The slowdown has been attributed to drought, although it may also be reflecting that a plateau has been reached in adoption of significant farming technologies (e.g. low till farming) coupled with greater within and between season variability in rainfall and frost.

Table 2: Selected measures of productivity (yield/ha harvested) improvement in arable and pastoral industries (Source: Robertson et al. 2010).[6]

	Rate of linear increase	Percent per year	Period	Comments
Grains				
Wheat	27 kg/ha/year	2.3	1970 -2000	slowdown since 2001
Barley	24 kg/ha/year	2.4	1962-2001	slowdown since 2002
Oats	26 kg/ha/year	2.5	1962-2001	slowdown since 2001
Sorghum	32 kg/ha/year	2.1	1962-2008	
Maize	92 kg/ha/year	4.2	1962-2008	
Rice	88 kg/ha/year	1.5	1968-2005	slowdown since 2006
Other crops				
Cotton lint	30 kg/ha/year	5.0	1964-2008	
Sugar	48 kg/ha/year	0.4	1962-2008	
Beef				
Weight at slaughter	2.2 kg/hd/year	1.5	1962-2008	
Lamb				
Weight at slaughter	0.19 kg/hd/year	1.1	1987-2004	slowdown since 2005
Dairy	82 L milk/cow/year	4.1	1962-2008	
Wool	No discernible trend in yield per head	-	1989 to 2009	Reduction in diameter of 1.8 µm

In general, cropping has outperformed livestock. An analysis of why this has occurred offer some salutary lessons for other industries. Increased understanding of cropping systems is the most frequently advanced reason for strong productivity growth in the 1980s and 1990s. This directly contributed to productivity growth by allowing farmers to make better decisions and, hence, use inputs more effectively to produce outputs. Practices include effective use of crop rotations, increases in fertiliser and ameliorant use, reduced tillage, and changes to cropping practices such as integrated weed management. New component technologies that have contributed to the productivity improvements include greater disease resistance of crop varieties, more efficient chemicals and fertilisers and larger, more sophisticated machinery that has allowed earlier sowing and retention of soil water. Singly they contributed to advances but also in combination they have aided the development of reduced tillage and controlled traffic systems, and have led to more efficient use of labour, fuel and capital and, to a lesser extent, yield improvements. All of these changes have increased the skills required of farmers, which in turn has increased the use of consultants and agronomists and the managerial capacity of grain growers.

The experience of the grains industry offers lessons for other industries where production increases have not been as strong.

Minimising the impact of weeds, pests and diseases

The annual costs of weeds (c. $6B), pests (c. $3B) and diseases (c. $3B) are significantly affecting agricultural production and commodity quality. While these costs are increasing, the rate of increase is managed through effective integrated pest management (IPM) and integrated weed management (IWM) as

[6] Robertson MJ 2010. in Proceedings of 15th Agronomy Conference 2010

well as Australia's national biosecurity system which is keeping Australia free of key pests (e.g. khapra beetle, Foot-and-mouth disease (FMD), and Xylella) that would shut access to some existing markets if we were to have an incursion. Despite this it has been estimated that the impact of endemic weeds, pests and diseases has a 25% impact on prices paid by consumers. While Australia has been a world leader in minimising antibiotic use in farm animals, which thereby helps minimise the development of antimicrobial resistance (AMR), we will need to do more in the future.

Growing the Australian agricultural business depends on:

a) Finding better ways to manage impacts of our existing pests, weeds and diseases, particularly for pests like wheat rust, Queensland fruit fly, and our notifiable animal diseases (e.g. bluetongue and mastitis), as well as the risks and quality impacts these have on our commodity export volumes and markets.
b) Keeping Australia free of the pest, weed and disease threat (including new pesticide resistant genotypes of biosecurity importance) that could suppress or shut down our current markets. For example, an outbreak of FMD could cost Australia $50B and shut down all export meat markets for an indeterminate amount of time.
c) Keeping on top of AMR with innovative approaches to widespread surveillance in the environment.

CSIRO undertakes wide-ranging relevant R&D to support these imperatives to keep Australian commodities low in pest and disease prevalence.

Avoiding land and water degradation

Australian agriculture rests on a fragile base. In general (but with important exceptions), soils have low nutrient and organic matter levels, the climate is highly variable compared to other major exporting countries, secured water resources are subject to substantial shortfalls and biosecurity risks are significant. Sustaining agriculture's base is a challenge over much of the continent. Despite improvements in agricultural practices, recent reviews describe increasing concerns around soil acidification, unsustainable rates of soil erosion, loss of soil organic carbon and nutrient imbalances. The continuing yield gap in Australian agricultural systems is only partly due to degradation of the base, but farms with better practices, more diverse cropping systems, regular soil testing and agronomic advice have smaller gaps and better returns.

We argue that an explicit concentration on understanding and managing the soil and water resource at farm level will allow amelioration over time and increase the resilience of agricultural systems. This is an important part of the promise of digital agriculture – the ability to anticipate, diagnose and respond to the health of the resource base.

Adapting to unavoidable climate change

The impacts of climate change are already being seen in Australia's agricultural production and will continue to be seen far into the future, regardless of what happens to atmospheric global greenhouse gas levels. Impacts touch every industry and are as diverse as: an increase in the duration and severity of heatwaves reducing milk production in dairy cows, later and more erratic opening winter rains and therefore crop establishment in the southern cropping areas, floods and heatwaves impacting on the yield and quality of fresh horticultural produce, reduced irrigation supplies and planted area in the cotton industry, compressed vintage periods in the wine industry, and wider frost windows affecting frost-sensitive cropping industries.

The increasing frequency and severity of extended dry spells, associated with increased unpredictability of unseasonal heatwaves and frosts, will impose a noticeable handbrake on growth in farm gate output, particularly in southern Australia. On-going adaptation will be required by farmers and agribusiness. CSIRO is preparing to launch a national mission in "drought resilience". It will address the concern about diminishing scope for incremental innovation to maintain productivity, let alone grow it, in the face of increasing climate risk. The mission, in partnership with ABARES, the Bureau of Meteorology and Geoscience Australia, will create information, tools and options to accelerate farm and community adaptation, foster new high value-adding agri-food industries, protect land and water resources and anticipate and manage biosecurity threats.

Prospects for increases in price per unit product

Australia's agri-food sector is presented with an unprecedented growth opportunity. There are over three billion middle class consumers emerging to our north in the next few decades. Asian food markets are projected to increase 2.5-fold by 2050. We are not alone in observing this opportunity consequently we have competitors. For example, there has been a 3-fold growth in Brazilian agricultural exports since 2000. Much of this opportunity will comprise of value-added and premium products.

CSIRO produced the Food and Agribusiness Roadmap[7] in July 2017 to support Australian food and agribusiness in its transition to a collaborative, growth oriented, high value-adding and differentiated sector. The roadmap discussed industry trends and opportunities, and identified key science, technology and business enablers for industry. In considering Australia's competitive position in this global market, three growth opportunity themes and 10 opportunities were identified as part of the roadmap:

Products for health and wellbeing: Foods and beverages that provide specific health benefits above and beyond basic nutrition, and target consumers who are either health conscious or have specific medical/dietary needs. Key opportunities include free-from and natural foods, fortified and functional foods, vitamins and supplements, and personalised nutrition.

Sustainable solutions: Environmentally and socially responsible manufacturing processes and products, and the recovery of novel, value-added products from waste streams. Key opportunities include organic waste conversion, sustainable packaging and alternative protein sources.

Premium interactions: Products that yield a premium price due to quality and convenience, luxury status, novel attributes or their integration with food-based experiences. Key opportunities include convenience meals, luxury and novel products, agritourism and experiences.

CSIRO has recently published a new economic analysis of the opportunities identified in the 2017 Roadmap[8]. It considers factors such as trends in consumer preferences, competitive advantages, potential competitors and substitutes, and broader macroeconomic forces such as population and income growth.

CSIRO analysis estimates that the opportunity for health and wellness foods, sustainable solutions and premium segments, as identified in the roadmap, to grow at around 3.6% per annum to a value of $25B by 2030. These markets are likely to be important sources of growth for Australian food and agribusiness over the next decade if industry can capture the opportunities. This can be compared to the National Farmers' Federation strategic target to reach $100B in farm gate output (defined as gross value of Australian farm production) by 2030, which similarly expects a growth rate of approximately 4% per annum.

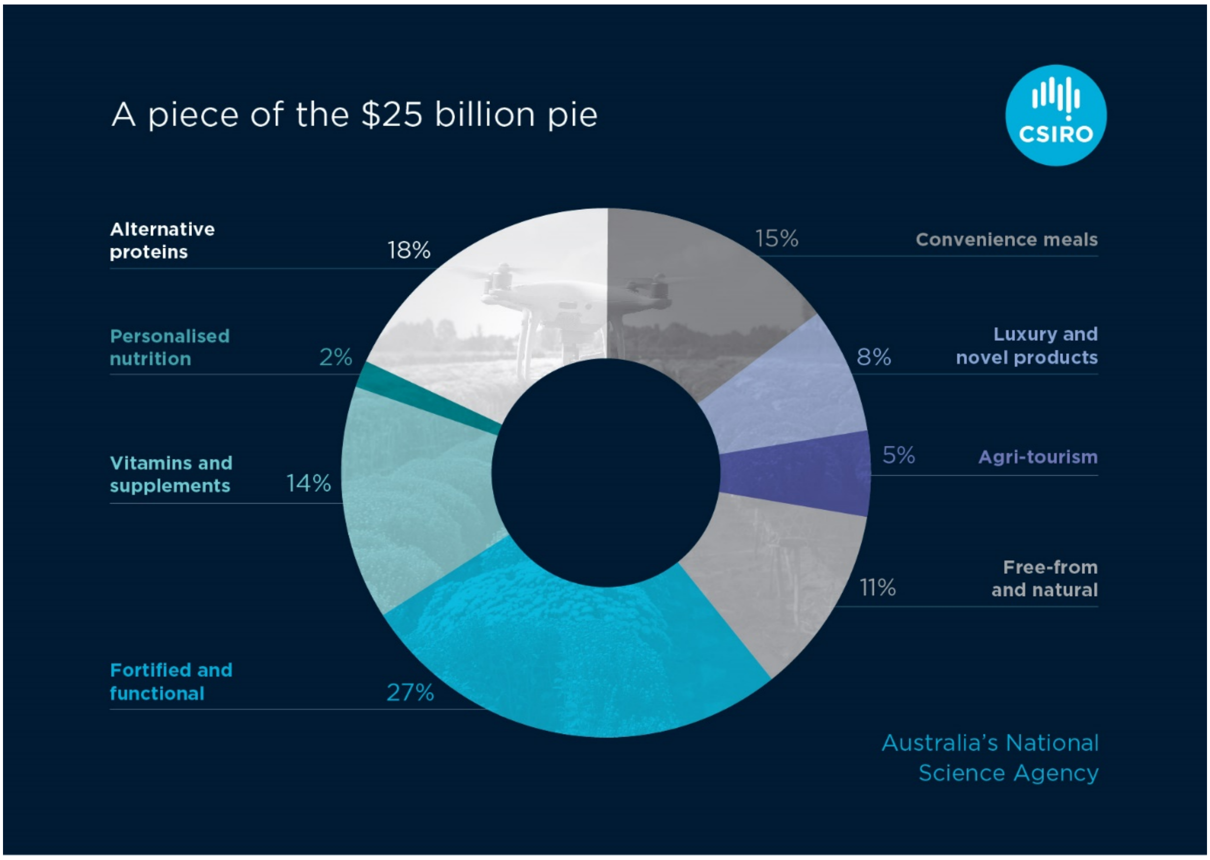
This growth will require investment in science and technology to create the next wave of products and services that will meet the needs of tomorrow's global customers.

CSIRO has been associated with developing food products designed to capture more value from commodities. For example, omega-3 into canola, low gluten in barley, high amylose wheat, and high resistant starch barley. Boutique brands, sustainability credentials and provenance offer the promise of greater value.

In order to capture the opportunity of premium, high-value markets in Asia, the agri-food sector needs to continue on its journey of "de-commodifying" the major outputs. One opportunity that CSIRO is focusing on is in protein and is preparing to launch a "Future protein" mission that will develop value-added premium protein ingredients.

[7] https://www.csiro.au/en/Do-business/Futures/Reports/Food-and-Agribusiness-Roadmap

[8] https://www.csiro.au/en/Do-business/Futures/Reports/Opportunities-for-Food-and-Agribusiness



Global protein consumption rose 40% between 2000 and 2018 with more than 50% of this increase driven by Asia. Future protein demand is being driven by growing middle class and urbanisation rates. As compared to 2018 levels, global protein demand is projected to grow by up to 20% by 2025. However, with global resource constraints putting limits on animal-derived protein production, and ethical and sustainability concerns from consumers about animal production, alternative and more sustainable sources of protein offer an opportunity to fill this gap. Alternative protein products derived from sources such as seeds, pulses, nuts, bacteria or mycoprotein, microalgae, and insects are in high demand to complement traditional sources of protein in our diets. The Mission will enable Australian breeders, growers, processors and producers to capitalise on the rapid growth of the protein-based sector and give access to new (export) markets for wealth creation.

Unfortunately, much of the effort in the agri-food sector separates raising on-farm productivity from the crucial whole of chain costs and value and market drivers. More linking of pre- and post-farm gate issues will lift the performance of the whole value chain. We have argued for the need for market road maps that connect the opportunity with the associated innovation challenge and will send more effective R, D, & E signals to industries and knowledge institutes. The launch of the Industry Innovation Precincts and Industry Growth Centres hold promise as a step in the right direction, but much more needs to be done to re-balance, streamline, and improve the connectedness of Australia's agri-food innovation ecosystem to market opportunities.

The role of R&D in reaching the goal

The precise level of investment in agricultural and related R&D in Australia is unclear but it is of the order of $1.4 billion per annum. About 40% of the expenditure for agricultural R&D comes from the Australian government. Cross subsidies enable funds to flow from the education to research functions in Universities and this adds to the lack of transparency in the public funding of R&D. The remaining 60% is evenly split between state governments, levy payers, and investments by agribusiness. The RDCs now fund around $500 million annually, comprised of farmer levies and matching government funds. This has grown from around $200 million per annum over the past twenty years and is now the largest single source of rural related research funds. RDCs now have a major influence on the whole R&D system given both the direct funding they control plus a similar amount of public funding they leverage across the entire system.

The slowing of productivity mentioned above has been linked by some researchers to a declining R&D spend (in absolute and research intensity terms). Others have argued that it is due to a small percentage contribution by the private sector, at least compared to other OECD countries. Regardless of these arguments, it is incontrovertible that while Australia ranks favourably on the international scale for expenditure on R&D, and on the volume and quality of research outputs, it ranks poorly for the rate of translation from research inputs to outcomes for end users. Our contention, which is supported by others, is that the interactions between farmers, agribusinesses, supports services, markets and consumers and a raft of organisational and sector policies required to make productive use of ideas and technology in entrepreneurship and innovation are lacking, and hence much of the activity in the innovation system is not driving productivity improvements. We have argued elsewhere for a number of reforms and innovations to the agri-food R&D system[9].

We acknowledge that R&D is not the only factor that will drive gains in farm gate output. We acknowledge that areas such as capacity building, access to labour, innovation in business models, marketing initiatives, and value adding will also be important. Lowering costs and ready access to cheap capital will also be critical.

Cross-cutting R&D issues in reaching the goal

The enabling role of digital agriculture

A recent project highlighted that the development and adoption of digital technology by farmers could increase farm gate value by $20 billion per year[10]. We agree that farming will be increasingly data-driven. This will be fuelled by advances in weather and climate forecasts, more dynamic and timely information on the state of soils and crops, and linkages with farm management software to improve operational efficiency, safety and transparency. Large volumes of data will be able to be generated by cheap, ubiquitous sensors. A growing stream of private data, much of it farmer-derived, will stimulate services from a wider range of providers. Routine tasks will be automated, and data and analytics bought to bear on more complex decisions.

Greater ubiquity, automation and accessibility of decision tools means they are likely to reach a far greater audience – agronomists, farm consultants, banks, insurers, marketers, input suppliers, bulk handlers, and consumers. CSIRO invests into R&D in digital agriculture, creating platforms for use across industries, commercialising tools for end users, generating new datasets, and conducting research to understand social implications and risks. We have also invested in companies in this area in order to try new ways to deliver our research and thereby improving the rate of translation. We envisage digital systems enabling farmers to respond to increasing pressures and opportunities for regulatory compliance, product provenance and best management practice. However, digital agriculture is in the middle of a heightened 'hype' phase. Lessons from the past need to be heeded[11].

Export supply chains, market access and food regulatory systems

Australia producers and manufacturers have a quality advantage over companies in Asian countries due to Australia's stringent regulatory system, skilled workforce and reputation to produce trusted, high quality

[9] Robertson MJ et al. 2016. Five ways to improve the agricultural innovation system in Australia. *Farm Policy Journal* 13: 1-13

[10] http://farminstitute.org.au/p2dproject

[11] Robertson et al 2019. Digital agriculture in (Eds. J Pratley and J Kirkegaard) "Australian Agriculture in 2020: From Conservation to Automation"

'clean and green' products. However, at the same time, global competition is stronger than ever and the current trade environment has heightened the risk of non-tariff trade barriers. Technological advancements are transforming global supply chains and offer the potential to automate regulatory compliance and the move from inspection to verification of supply chain integrity. Consumers are also demanding more information about the products they are using, including their provenance, whether they have been produced ethically and sustainably in addition to their safety, quality and health credentials. Our domestic food regulatory system is outdated, one of the costliest in the world, with prescriptive regulatory approval processes which are not proportional to risk and can reduce system flexibility and innovation. Technological and digital maturity of our food supply chain is generally low, and there is significant opportunity to leverage a range of modern technologies (e.g. AI and digital traceability technologies) to build efficient and robust supply chains.

CSIRO is preparing to launch a "Unlocking Food Export Value" mission that will continue to build the evidence base that underpins the trust and market access of Australian products. This mission will be focussed on building market access through systems to ensure supply chain integrity for commodity quality, safety and a low prevalence of trade-relevant pests and diseases. We are also developing considerable capability in digital platforms and technologies in areas such as provenance and traceability, regulatory automation and value chain analytics.

Social licence to operate

The social license to operate of many industries in the agri-food sector are coming under increasing pressure – such as competition for water between irrigators and the environment, concerns about poor animal welfare, and the impact of current farming practices on soil and water resources during extended droughts. While many of these issues are highly emotive and driven by strongly held values, there is a role for R&D to provide an evidence base for discussion as well as to understand the social context, changing attitudes and behaviours, and quantify the benefits and costs of various choices. CSIRO sees an increasing demand for multidisciplinary research that addresses the social license to operate. Our research on animal welfare, water use by irrigated crops, land management practices, and social issues can be bought together in powerful ways to provide a holistic view of issues and chart a way forward that accounts for multiple stakeholder points of view.

Incremental transformation

The challenge to meet the $100B goal has prompted many to propose the need for 'transformational change' in Australian farm production systems through technological 'breakthroughs'. These transformative technologies are often distinguished from the 'incremental' advances generated by agronomy and breeding which are dismissed as business as usual, and inadequate to achieve the productivity improvements sought. However, when viewing small but consistent annual gains in productivity over the last 30 years, the change is truly transformational, but the transformation has come through incremental gains largely due to many disparate technologies combining to form a coherent system. It may seem negative to be critical of aspirations to achieve transformational breakthroughs, but in a world of diminishing expenditure in agricultural research it will be important to target dwindling funds well. Proposed transformational changes often focus on one component of a system championed by largely disconnected research disciplines. In reality, and throughout history, few individual technologies have been singularly transformational either in the scale or the speed with which they have influenced productivity. Rather, step changes in productivity have come only when combinations of technologies, often a mix of old and new, synergise within a system.

We argue if the required increases in farm gate output are to be achieved, there will be a critical role for systems thinkers (such as agronomists) as directors and integrators of multidisciplinary research teams that are formed specifically to address significant constraints to production. They have the generalist science knowledge to understand which specific fields of research can be brought to bear on a challenge or opportunity, and how different fields must interact with each other to exploit synergies and avoid tradeoffs to form tractable solutions. They also have familiarity and credibility with farmers that is required to test research findings in the right context to ensure adoption and impact.